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**A61B 5/0452 // A61B 5/04 , G06F 17/00**

(52) UK CL (Edition V )
**G1N** NECG

(56) Documents Cited
**WO 2002/000113 A1** **WO 2000/062668 A1**
**US 5792065 A** **US 5560370 A**
**US 5560368 A**

(58) Field of Search
UK CL (Edition V ) **G1N**
INT CL[7] **A61B, G06F**
Other: **Online: WPI, EPODOC, PAJ.**

(54) Abstract Title
**Electrocardiogram QT interval measurement**

(57) A method to measure the QT interval (5, figure A) of a digitised electrocardiogram (ECG) waveform comprises squaring amplitude values of electrical heart activity measured by three orthogonal X, Y, Z ECG leads (figure 1) and then summing the squares of the amplitude values at corresponding times to give a squared resultant waveform (figure 2). The QT interval is then measured from the resultant waveform. The resultant waveform may be inverted to create a reflected waveform, the intersection of the original upright waveform and the inverted waveform being used to define the end of the T-wave.

FIGURE 2

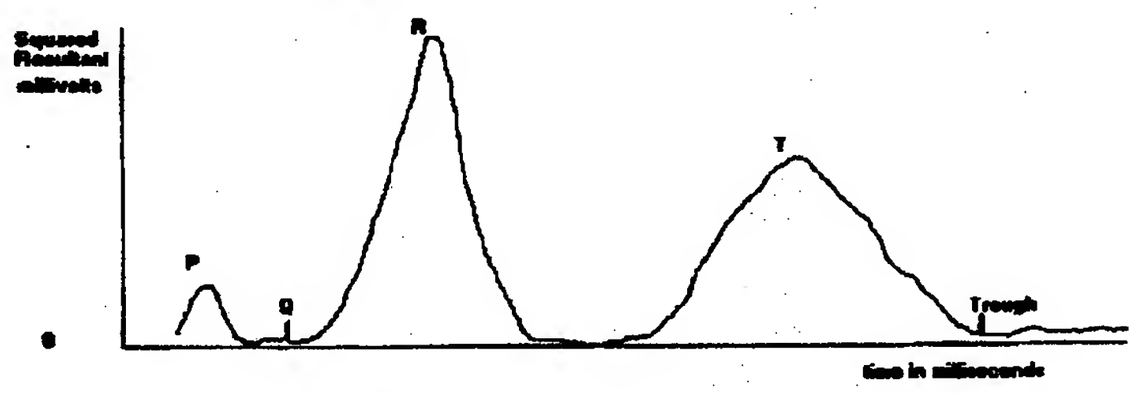
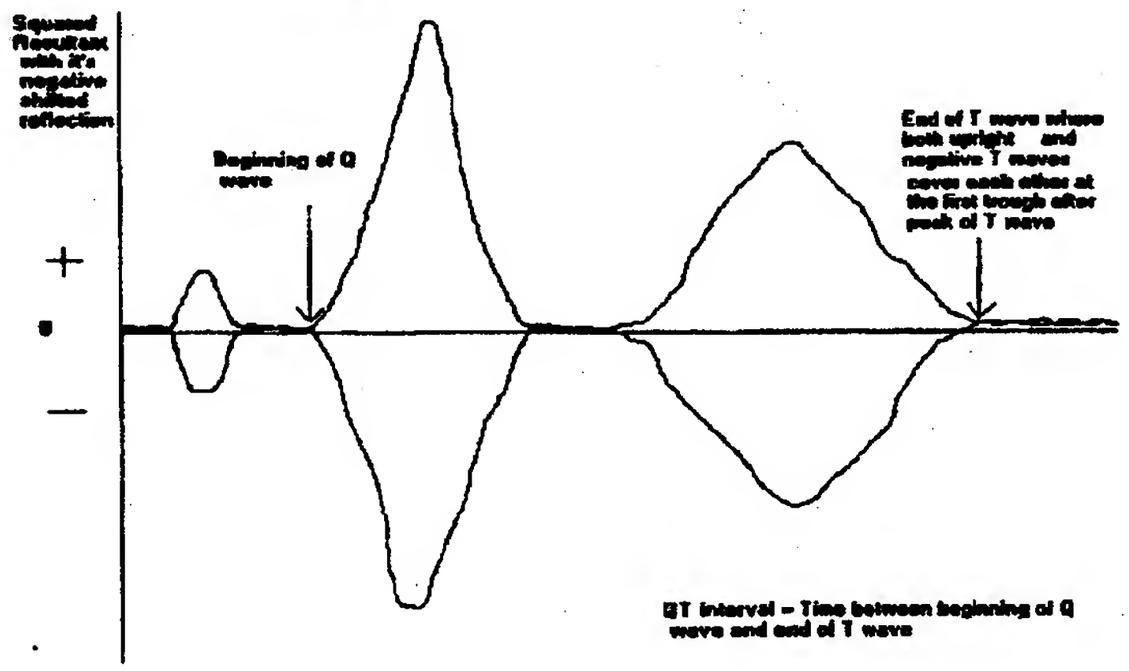



FIGURE 3




The claims were filed later than the filing date but within the period prescribed by Rule 25(1) of the Patents Rules 1995.

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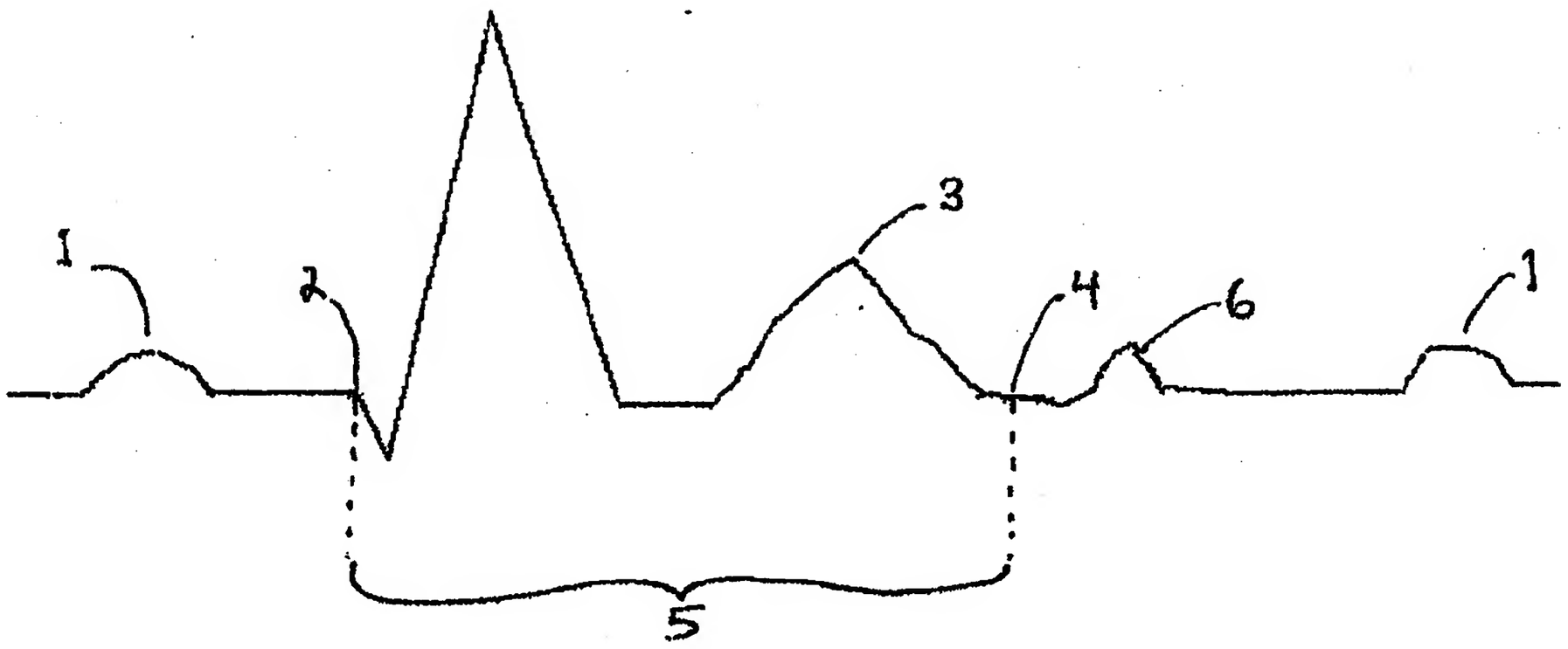



FIGURE ~~XXX~~ A.

FIGURE 1 (A, B and C)

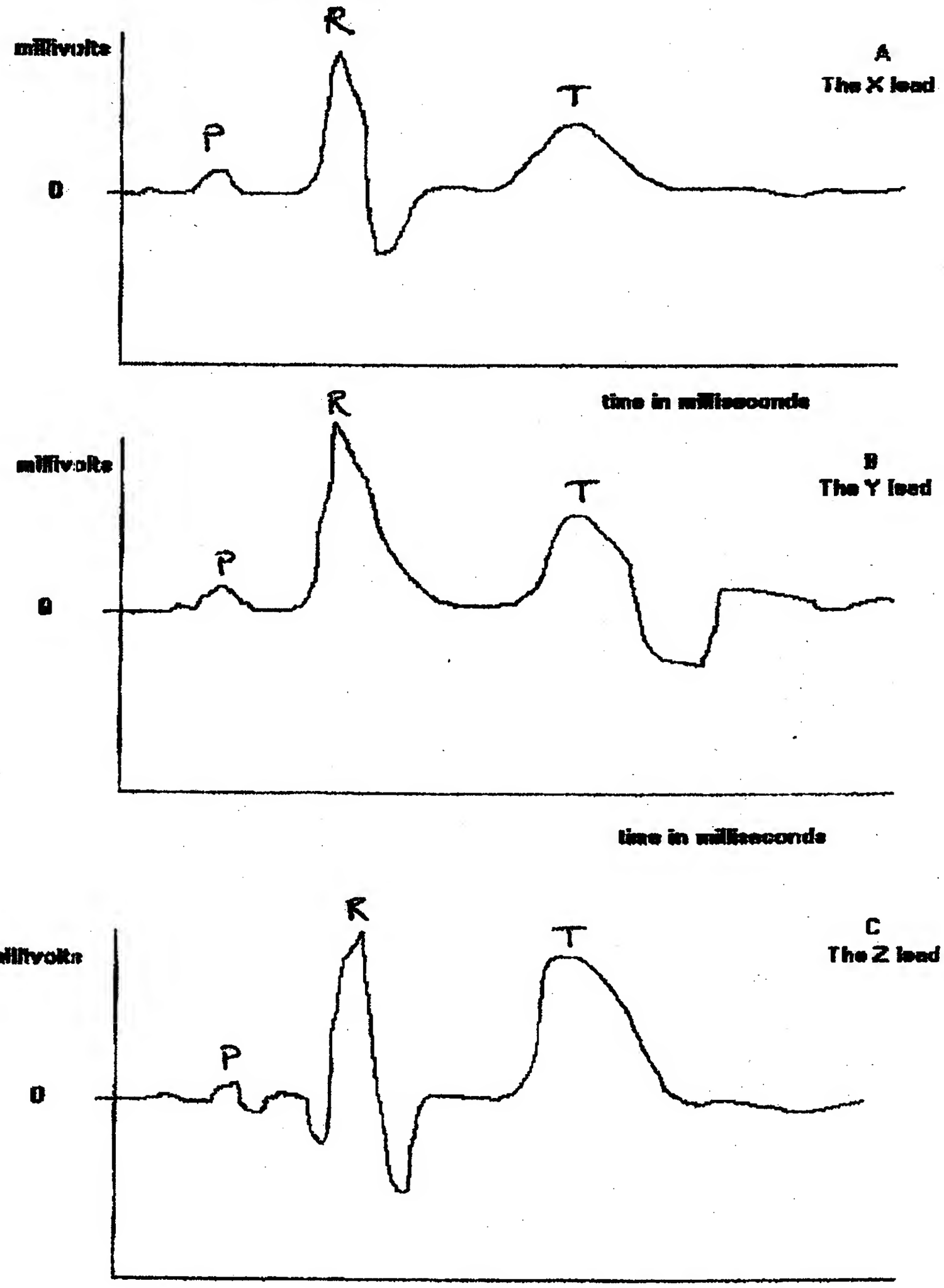


**FIGURE 2**

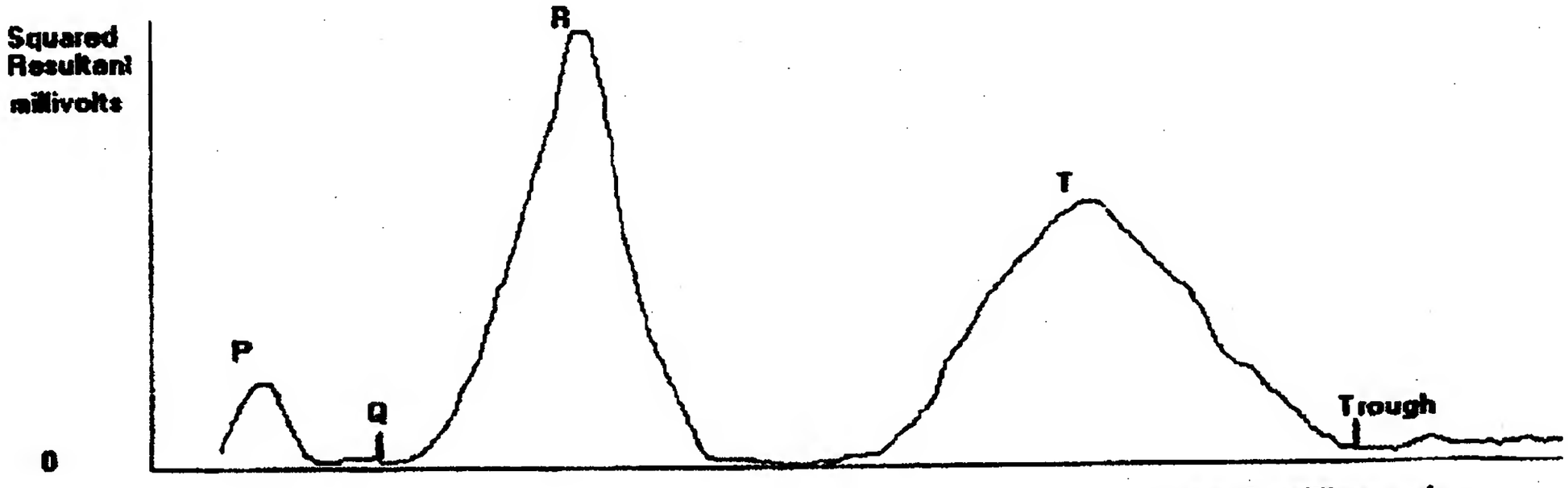
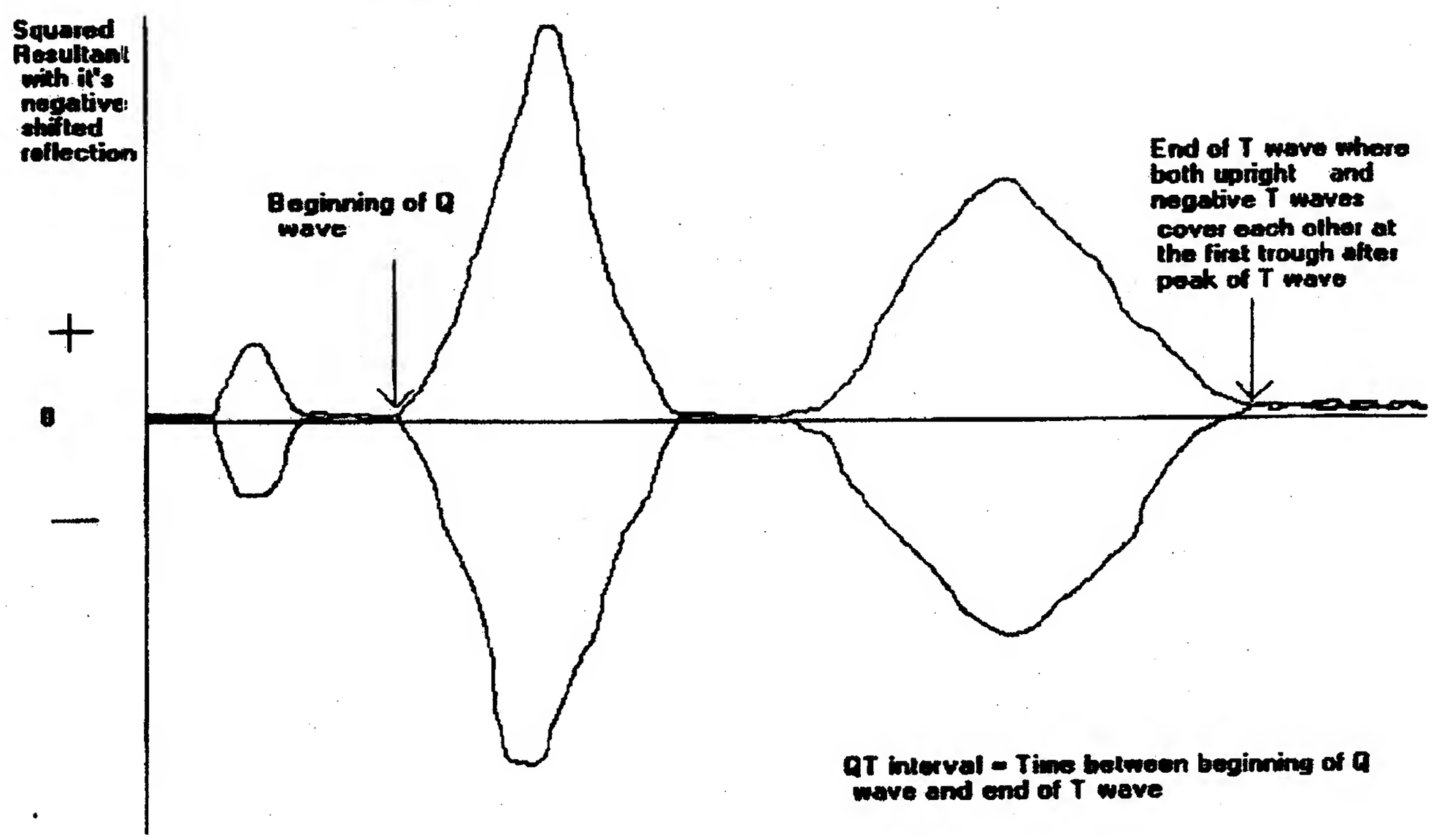

Squared
Resultant
millivolts
0
R
T
P
Q
Trough
time in milliseconds

**FIGURE 3**




QT interval = Time between beginning of Q wave and end of T wave

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# Electrocardiogram QT Interval Measurement

The present invention relates to a method of measurement of the QT interval on an electrocardiogram, and to an electrocardiogram apparatus using the method.

An electrocardiogram measures the instantaneous voltage potential difference of a hearts electrical activity in a number of lead vectors. It is common to use 12 different lead vectors, although it is also known to use "Franks Leads" where three orthogonal X,Y and Z leads are used. The duration of certain types of waves within the ECG give very important information. One important interval is the QT interval which is approximately 400ms in duration.

An average increase in the QT interval of as little as 5-10 milliseconds during pharmaceutical drug testing indicates the potential for the drug to induce a fatal cardiac rhythm disturbance when more widely prescribed. Therefore accurate measurement of the longest QT interval in the standard 12 lead ECG is of paramount importance when assessing the safety of a new drug.

There are no problems with the accurate timing of the onset of the QT interval, but there are problems with the accurate timing of its ending as illustrated in Figure A. A single lead is shown in the graph of Figure A with the X axis representing time in milliseconds and the Y axis representing millivolts above and below the isoelectric baseline. In Figure A, 1 is the P wave, 2 is the onset deflection of the Q wave (the start of the QT interval), 3 is the peak of the T wave, 4 is the approximate end of the QT interval, 5 is the QT interval duration, and 6 is the U wave.

The start of the QT interval is easily timed at 2 when the wave starts to be a high frequency negative or positive deflection from a "zero" baseline value. The end of the QT interval is in theory the point at which the T wave dissects the isoelectric baseline ( a theoretical line of constant milli voltage at the cessation of the T wave). This point in time, as shown, is not clear because of the low frequencies defining the time point, because of the presence of a prominent U wave which may merge and superimpose itself with the end of the T wave, and because of the presence of low frequency drift.

Inaccuracies also arise in the measurement of a QT interval in a given lead when an apparent change in QT interval duration may be caused by a change in the direction of the resultant vector in three dimensions without any real change in the duration of the three dimensional resultant vector of QT duration.

It is known to use automated computer algorithms to measure the QT interval in a given ECG lead, but these are not considered any more accurate than expert manual measurement.

The invention seeks to provide a solution to this problem.

According to the present invention there is provided a method of measurement of the QT interval on an electrocardiogram comprising, measuring the millivolt amplitude and millisecond timing from X,Y and Z orthogonal leads from ECG electrodes, squaring and summing the millivolt amplitude values from each of the X,Y, and Z orthogonal leads to create a first waveform of

squared resultant vector values, and measuring the QT interval from the onset of the Q wave and the end of the T wave from the first waveform when the T wave hits the isoelectric baseline.

The T wave may hit the isoelectric baseline when the T wave reaches the first trough after the peak of the T wave. The trough may be defined as when there is no difference in millivolt amplitude of the electro cardiogram over a 20 millisecond duration.

Preferably the method further comprises smoothing the end of the T-wave high frequencies to help define when the T-wave millivolt value is ended.

Preferably the method further comprises inverting the first waveform to create a second waveform reflected in the isoelectric baseline, and defining the end of the T-wave when the end of the T-wave and inverted T-wave intersect.

The invention also extends to an apparatus which uses the above method of measuring the QT interval.

The invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows graphs of waveforms derived from three orthogonal leads X,Y,Z

Figure 2 shows a graph of a first waveform from squared and summed amplitude values from the waveforms of Figure 1, and

Figure 3 shows the graph of the first waveform of Figure 2 and an inverted waveform.

Referring to Figure 1 there is shown graphs of the millivolt amplitude against millisecond timing measured from X,Y and Z orthogonal leads of ECG electrodes. The peak of the R wave is shown as R and the peak of the T wave is shown at T. Positive and negative millivolt amplitude values are shown above and below the X axis.

The millivolt amplitude values from each of the X,Y, and Z orthogonal leads are squared and summed to create a first waveform of resultant vector values as shown in Figure 2. The QT interval is then measured from this first waveform from the onset of the Q wave and the end of the T wave when the T wave hits the first trough after the peak of the T wave. Because this wave shows the resultant millivolt vector value, it necessarily shows the longest QT interval.

A first advantage of squaring the amplitude values from each of the orthogonal leads is that any negative values become positive so there are no values below the zero millivolt baseline. A second advantage of squaring the amplitude values from each of the orthogonal leads is that millivolt values under "1" become smaller so there is an inherent smoothing for small values, which makes identification of the trough more accurate, i.e. more easily identifying when the wave effectively hits the isoelectric baseline.

As shown in Figure 2 the point when the T wave first hits the trough is the point where the T wave ends. In this respect it may be desirable to further smooth the end of the T-wave and isoelectric baseline high frequencies to define when the T-wave millivolt value more accurately first hits the trough and is thus ended.

Measuring the QT interval by squaring the millivolt amplitude values each of the X,Y, and Z orthogonal leads as shown in Figure 2 is the broad method of the invention.

The measurement of the QT interval may be further enhanced by inverting the first waveform to create a second waveform reflected in the baseline, and defining the end of the T-wave when the end of the T-wave and inverted T-wave intersect. This is shown in Figure 3. As shown in Figure 3, the end of the T-wave can be clearly seen when the first and second waveforms intersect. It can be seen that this coincides with the beginning of the first trough after the peak T wave and in effect negates the potential error of isoelectric baseline drift.

It is envisaged that an ECG apparatus would be produced for performing the method of the invention. The apparatus would take the electrical signals from the X,Y,Z orthogonal leads and measure these in millivolts against a time base of milliseconds. The apparatus would square the millivolt values of each lead and the sum these using an appropriate algorithm. An algorithm would then be applied to the squared sum to create an inverted value and the inverted waveform then shifted upwards along the vertical axis until the first trough following the peak T wave of the first waveform and the second waveform are transposed over each other to give a best least squares fit. The QT interval could be measured electronically and displayed using a further algorithm or it could be derived from a graphical print out similar to that shown in Figure 3.

Further modifications of the invention will be apparent to those skilled in the art without departing from the scope of the present invention.

# CLAIMS

## Electrocardiogram QT interval Measurement

**Claim 1.** A method to measure the QT interval of a digitised electrocardiogram (ECG) comprises squaring the amplitude of a given or orthogonal lead, summing the squared amplitudes of the orthogonal leads at corresponding times to give a squared resultant vector ECG containing the longest QT interval. Measuring the end of the T wave as that first point in time at which the inverted/reflected version of the T wave intersects with the original T wave along the isoelectric baseline within the trough following the peak of the T wave.

**Claim 2.** A method to measure the QT interval as claimed in Claim 1 applied to a single or combination of ECG leads from a 12 lead ECG.

**Claim 3.** A method to measure the QT interval as claimed in Claim1 using a filtering method to smooth the ECG without phase distortion which will enhance the accuracy of the method.

**Claim 4.** A method to measure the QT interval as claimed in Claim 1, Claim 2, and Claim 3 provided by a computer software algorithm incorporated into ECG machines which will enable measurement of the QT interval at the time an ECG is recorded.

**Claim 5.** A method to measure the QT interval described herein with references to Figures A,1,2 and 3 of accompanying drawings.

INVESTOR IN PEOPLE

**Application No:** GB 0208115.6 **Examiner:** Eleanor Thurston
**Claims searched:** 1 at least **Date of search:** 24 July 2003

# Patents Act 1977 : Search Report under Section 17

**Documents considered to be relevant:**

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance | |
|---|---|---|---|
| A | - | WO 00/62668 A1 | (BEVERLY GLEN MEDICAL SYSTEMS, INC.) |
| A | - | WO 02/00113 A1 | (MEDI-WAVE STAR TECHNOLOGY, INC.) |
| A | - | US 5792065 A | (XUE et al) |
| A | - | US 5560370 A | (VERRIER et al) |
| A | - | US 5560368 A | (BERGER) |

Categories:

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|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
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| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |

## Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

G1N.

Worldwide search of patent documents classified in the following areas of the IPC[7]:

A61B; G06F.

The following online and other databases have been used in the preparation of this search report:

EPODOC, WPI, PAJ.